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THE MINERAL RESOURCES OF THE STATE OF RIO GRANDE DO SUL, BRAZIL.

A PAPER READ BEFORE
THE INSTITUTION OF MINING ENGINEERS.

BY

H. KILBURN SCOTT.

GENERAL MEETING AT LONDON,

JULY 2ND, 1903.

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THE MINERAL RESOURCES OF THE STATE OF RIO GRANDE DO SUL, BRAZIL.

By H. KILBURN SCOTT.

Introduction.—During the last few years an increasing amount of interest has been taken in mining work in Brazil, and this is partly accounted for by:—(1) The depreciation in the value of the national currency, making the opening of any mining property relatively easy, as compared with the conditions obtaining when exchange is near par, as in 1890. This depreciation was most pronounced during a part of 1899, when the milreis, which has a par value of 2s. 3d., fell to 5½d. And (2) the profitable development of the manganese-ore industry, which was initiated in 1895, and the successful re-opening of the famous Morro Velho gold-mine, which gave a distinct fillip to mining work.

In no part of Brazil was the interest in mining felt more keenly than in the state of Rio Grande do Sul, and during the last few years, several companies have been formed to work metalliferous and other deposits in this state.

General Remarks.—The state of Rio Grande do Sul is the southernmost of the United States of Brazil, and it is bounded on three sides by the state of Santa Catharina and the republics of Uruguay and Argentina, and on the fourth side by the Atlantic Ocean. Its geographical position is between 27 degrees 5 minutes and 35 degrees 45 minutes of south latitude, and between 6 degrees 22 minutes and 14 degrees 16 minutes of west longitude from Rio de Janeiro (Fig. 1, Plate XX.).

The language spoken is Portuguese, although, owing to the contiguity of the state to the Argentine and Uruguayan republics, many Spanish words are in general use.

The climate is most healthy, especially in the highlands of the interior, where the temperature seldom passes below zero, or above 35° Cent. It is very suitable for Europeans, as is

proved by the successful colonization of the district, north and west of Porto Alegre (the capital), by Germans and Italians: there being about 100,000 of each nationality.

As often obtains, the natives are intelligent but very indolent, and the presence in the country of the German and Italian colonists has had a most beneficial influence on them. The larger proportion of the natives earn their living directly or indirectly by the breeding of stock and the preparation of dried beef—principally for export.

The recent financial crisis brought about by the burning of paper-money, which was one of the obligations that the country took upon itself in 1899 in order to keep faith with its foreign creditors, has made itself felt in the state of Rio Grande do Sul, and most severely in those parts of it in which the fresh and dried meat-trades were hitherto the principal industries.

Efforts are being made throughout Brazil to establish new industries, and mining, because it develops the natural resources of the country, is having its share of attention; although it must be explained that latterly the abnormal rise in the gold value of the national currency from 6d. to 1s. per milreis has caused a temporary set-back to mining work, by reason of the consequent increased cost, in gold, of labour and materials bought in the country. Already the currency value of labour, etc., has fallen, and it may be taken that once the transition-stage is passed, not only will the country be able to satisfy its foreign bondholders, but the native industries, being supported by a solvent country, will become more profitable than heretofore.

The great recuperative power of Brazil is proved by its present financial stability as compared with 1899, when universal bankruptcy appeared to be inevitable; and the country is so rich in natural resources that three years has sufficed to accomplish what would have taken a decade in other countries.

The three principal towns are Rio Grande, Pelotas, and Porto Alegre, the state capital. The first-named is situated immediately inside the "bar," where the estuary of the Rio Grande empties into the Atlantic Ocean. The Rio Grande bar is somewhat shallow, but, if carefully navigated, steamers up to 5,000 tons burthen can reach the town. Pelotas and Porto Alegre are at the southern and northern extremities respectively of the Lagõa dos Patos (Ducks' Lagoon), a large and shallow lake which drains

the greater part of the state. Pelotas is a flourishing commercial town, the centre of the cattle-trade, whereas Porto Alegre is more official in character.

The important towns in the interior are Bagé, San Gabriel, Santa Maria and Cachoeira, the two former being in the centre of the cattle-breeding district, and all of them are situate within the limits of the metalliferous region.

The railway-system passes through the more important towns and consists of a line of 1 metre-gauge, part of it from Rio Grande to Bagé being worked by a British company, known as the Brazilian Great Southern Railway of Rio Grande do Sul; while the rest of the system from Bagé by San Gabriel to Margem on the Jacuhy river (where it is joined to Porto Alegre by river-steamers) is leased from the government by a Belgian company. Another line, built by a Belgian company, runs from Santa Maria in a northerly direction, and is intended eventually to join the railway-system of the northern states. As most of the lines have a guaranteed interest, the Brazilian government is reducing its foreign obligations by gradually buying out the foreign companies, and leasing the lines again at a remunerative rate; and it is likely that it will eventually acquire the British railway above mentioned, and lease it to the Belgian company, which works the rest of the line. None of the railways have, as yet, been very remunerative, but the British line has been the most successful, and it is to be presumed that the Belgian company will make an effort to obtain a lease of it with a view to more economical working being possible by having the through system under one management. The gradients on the railways are very heavy, in some places as much as 3 per cent., and the curves are severe, as small as 328 feet (100 metres) radius, but improvements could be made by proper contouring. In the vicinity of the coast-towns, and for some distance into the interior, the country is very flat: this being especially the case near the Lagõa dos Patos.

Generally speaking, the country is not mountainous, the higher lands consisting of low, rounded hills, except in the conglomerate-region where some of the hills are very steep. In consequence of the large area of eruptive rocks, and the absence of the decomposed metamorphic schists, which are so prominent a feature in other parts of Brazil, the roads are easy of transit.

Geology.—The geology of the state of Rio Grande differs considerably from that of the state of Minas Geraes.*

In the southern part of the state, there is a chain of hills rising to 2,000 feet (600 metres) above sea-level, known as the Serra do Herval, and consisting in great part of granite and eruptive rocks. In the western part of the range, the granite gives place to gneiss, fine and coarse porphyries, metamorphosed chloritic schists, etc., and these extend into the Republic of Uruguay. The metamorphic schists are intersected by veins of auriferous quartz, in which the gold is sometimes visible, but it is generally associated with iron-pyrites.

The Carboniferous formation extends along the northern side of the Serra do Herval, and consists of soft sandstones, shales and coal-seams, producing a coal of a semi-bituminous and schistose character at the principal mine, known as São Jeronymo.

In the south, huge deposits of conglomerate are found over an extensive area, which have been disturbed by a large eruption of melaphyre. They are made up, for the most part, of granitic material with a small proportion of the débris of metamorphic rocks, quartzites, micaceous and chloritic schists, and the constituents vary in size from large boulders to the finest particles forming a sandstone. Thin layers of materials of even size, alternate with each other, and the fine conglomerates and sandstones seem to be by preference in the lower, and the coarser conglomerates in the upper portion of the series. The beds generally lie horizontally, but they have been broken in every direction; and parts have fallen down, while masses stand 175 to 200 feet (50 to 60 metres) higher with sharply-defined escarpments.

In many places, the eruptive rock not only appears on the surface, but has covered the hills with a lava-like flow. Besides this main movement, the conglomerates have been subjected to local upheavals: the principal one, of which the Camaquam copper-mine is the centre, is 12½ miles (20 kilometres) long and 4 to 5 miles (6 to 8 kilometres) wide. The beds are inclined on both sides at an angle of 40 degrees, and in many parts the melaphyre appears on the surface. At the Cerro Martino, the

* "The Manganese-ores of Brazil," by Mr. H. Kilburn Scott, *Journal of the Iron and Steel Institute*, 1900, vol. lvii., page 179; and "The Iron-ores of Brazil," by Mr. H. Kilburn Scott, *Ibid.*, 1902, vol. lxi., page 237.

disturbance of the conglomerate and sandstone-beds is much greater; and pieces of them, surrounded by the melaphyre, form islands of sedimentary rock.

Copper occurs frequently in the whole region, which has been affected by the melaphyre-eruption, and there seems to be a close connection between the metalliferous deposits and the eruptive rock.

On the south-west of the conglomerate-formation, syenite covers an extensive area. It is very often auriferous, the gold occurring either in quartz-veins, or as impregnations in the decomposed syenite-rock. The village of Lavras, at the eastern extremity of this formation, is at present the centre of the gold-mining industry, although work is being carried on intermittently at other places, such as São Sepé to the north and Bom Retiro, near São Gabriel, to the north-west.

To the south of the conglomerate-formation, the Carboniferous rocks extend as on the north. The principal deposits of this basin are known as Candiota and Santa Rosa, and are very extensive.

History.—Mining in this state has been carried on more or less intermittently for the past 50 years. In 1835, gold was discovered in veins at São Antonio das Lavras, the metal having previously been located in the neighbouring streams.

The gold-deposits at São Antonio das Lavras and the copper-deposits near the Camaquam river were originally worked on a small scale by Brazilian owners, but the concessions were subsequently acquired by a British company, known as the Rio Grande do Sul Gold-mining Company, Limited. A certain amount of exploratory work was carried on in the vicinity of Lavras and on the copper-deposits of Camaquam, but, for some reason which it is difficult to discover, owing to the lapse of time, work was gradually suspended and the mines abandoned. In 1898, attention was again directed to these metalliferous deposits, and three companies were formed to work the auriferous deposits in the vicinity of the village of Lavras, known as the:—(1) Vista Alegre Gold-mining Estate Company, Limited; (2) Société des Mines d'Or du Cerrito; and (3) Omnium Minier Lopes-Talhouarne: the first being a British company, and the other two, Belgian. Messrs. Belfort & Company, a local company, are opening up a

mine on the Bom Retiro estate, near São Gabriel, while the copper-mine of Camaquam, which had been worked for some years by Germans, has now passed into the hands of the Société des Mines de Cuivre de Camaquam. This latter is a Belgian company organized by the Banque d'Outre Mer, which holds the majority of the shares.

Of the Carboniferous deposits, the two best-known are São Jeronymo and Candiota, the former being the most extensively worked. So long ago as 1841, Dr. Perigot was engaged by the Brazilian government to report upon these deposits, and the São Jeronymo mine has been irregularly worked since about 1870. At the present time it is owned by a native company, known as the Companhia das Minas de São Jeronymo.

Auriferous Deposits.—As already remarked, the principal known gold-deposits occur in the vicinity of the village of Lavras, which is situate 37 miles (60 kilometres) north of Bagé and about 800 feet (250 metres) above sea-level.

The gold occurs, principally, in the syenite-rock in small stringers of quartz and impregnations (stockworks) in the enclosing rock on each side of them. The syenite, at its contact with the quartz-stringers, seems to be decomposed to a varying thickness, which amounts in some places to 6 feet (2 metres) or more, the quartz having presumably disappeared as a result of the action of the solutions carrying the gold, etc. The mineralization is irregular, and generally limited in area, the rock being found to be very rich in places but often pockety.

Galena, iron pyrites and zinc-blende occur associated with the gold, the first-named being considered a good guide for auriferous ground, although as a matter of fact no rule can be established, as non-auriferous galena is common.

Ordinary iron-pyrites is often very rich in gold, and parcels of pyrites, weighing a few tons, were shipped to England for reduction in the early stages of the exploration, containing from 500 to 700 grammes of gold per ton.

At São Sepé, 22 miles (35 kilometres) north-west of Caçapava, auriferous quartz-veins are plentiful over an area 12½ miles (20 kilometres) long by 4 to 6 miles (6 to 10 kilometres) broad. At one place, an auriferous quartz-vein cuts the granite and metamorphic rocks, close to their contact with the Carboniferous

formation. In fact, coal, mined about ½ mile (1 kilometre) distant from the auriferous deposit, is used to drive a 5 heads stamp-mill at the mine.

The quartz-veins vary in thickness from 1½ to 6½ feet (0·50 to 2·00 metres) and are fairly easy to follow, as compared with the stringers found in the syenite at Lavras. The gold is sometimes visible, and, as at Lavras, often found in rich pockets, so that it is difficult to estimate the average gold-contents of the lodes. Near the village of Dom Pedrito, situate 37 miles (60 kilometres) to the south-west of Lavras, the Barcellos Gold-mining Company worked some auriferous deposits about 15 years ago. This company suspended operations shortly after its formation, presumably owing to payable bodies of ore not having been found.

In the Republic of Uruguay, near Taquarembó, several deposits are being worked, which have much in common with those in Rio Grande, and are said to belong to the same formation. The gold occurs in thin quartz-veins and impregnations in the syenite and metamorphic rocks as at Lavras and São Sepé; and, as far as can be gathered, the deposits, which are known as São Gregorio and Cuñapirú, are being profitably worked.

Speaking generally, it must be confessed that, up to the present time, the working of the different auriferous deposits in the State of Rio Grande, has not been particularly successful, the difficulty being the small size of the quartz-veins and the irregularity of their gold-contents, owing to their pockety tendency. Mining operations are being continued by the several companies, and it is anticipated that results as good as those shown in Uruguay will be obtained before long.

Cupriferous Deposits.—The principal copper-deposit as yet known, namely, that of Camaquam, is about 50 miles (80 kilometres) from the Rio Negro station of the Southern Brazilian railway and 2 miles (3 kilometres) from the Camaquam river. The mine is situated on a large upheaval of conglomerate, on the south-eastern point of the formation, caused by the large melaphyre eruption which affected the whole country: the melaphyre appears in many parts on the surface, but is not found in the mine (Figs. 2 and 3, Plate XX.).

The zone in which mining is expected to be most profitable

is 1,600 by 2,600 feet (500 metres by 800 metres), and the average height above the lower adit is 250 to 300 feet (80 to 90 metres). The upper adit was driven 520 feet (160 metres) in a north-easterly direction, and cuts a dyke of gabbro, which does not come to the surface. Most probably, this eruption caused the opening of the veins which diverge from the dyke and supplied the materials (quartz and copper and iron sulphides) which fill the lodes. In some cases, small particles of copper-glance have been found in the gabbro, and dendrites of native copper have been found in the fissures of the conglomerate, close to the

FIG. 4.—VIEW OF THE SURFACE-WORKS AT THE CAMAQUAM MINE.

former rock. It is interesting to note that these dendrites present a similar appearance to copper that has been deposited by electrolysis.

The lodes have not proved to be so good in the sandstone-beds as in the hard conglomerate, as through the softer rock they lack regularity or even continuity. Of the four lodes at present being worked, three are cut by two adits, respectively 200 and 380 feet (60 and 115 metres) below the top of the hill, and the other by a level opening directly on the outcrop. This latter only contains copper-pyrites, the gangue being quartz with heavy

spar. The three former are similar, with copper-glance near the surface, and bornite, copper-pyrites and some iron-pyrites lower down.

The first lode, cut by the lower adit, shows only copper-glance, the vein being thin but rich, giving excellent ore very easy to concentrate by hand-sorting. The two other veins yield a mixed ore of copper-glance and copper-pyrites. The average thickness of the lodes worked during 2½ years has been 4 feet (1·25 metres), and the ore assayed 6½ per cent. of metallic copper, with about 19 pennyweights (30 grammes) of gold per ton.

FIG. 5.—ORE-DUMP, ETC., AT THE CAMAQUAM MINE.

The cars of mineral coming out of the mine are tumbled over a grizzly and perforated plate with 1 inch (25 millimetres) mesh. The mineral is sprayed with water and sorted by hand, the picked rich ore assaying 30 per cent. of copper. The barren rock is thrown away, and the remainder, which averages only 7 per cent. of copper, is dressed in a small concentrating plant with breaker, roll-mill, trommels, hand-jigs and round-buddles. The resulting concentrate averages 28 per cent. of copper.

The actual monthly output of the mine is 90 to 100 tons of ore containing 28 to 30 per cent. of copper, which is packed in

canvas-bags and sent to England. The ore is free from such impurities as arsenic, lead and zinc.

The Camaquam Copper-mines Company is, at present, erecting a plant for dressing 80 tons per day. The concentrates will be smelted so as to obtain a matte containing 50 to 60 per cent. of copper; and the monthly output is expected to be 220 to 250 tons of matte. The plant will be run by hydraulic power. The dam, built for the purpose, is 400 feet (130 metres) long and 52 feet (16 metres) high at the deepest point. It will hold a reserve of water sufficient to run the mill during the whole year, so that the plant will not be stopped by the long droughts which sometimes occur.

FIG. 6.—VIEW OF DAM IN CONSTRUCTION AT THE CAMAQUAM MINE.

With regard to the continuation of these lodes in depth, as bearing not only on the future of these deposits but also on others in the same district and found under somewhat similar conditions, the author saw no evidence of any probability of their giving out. Although, on being opened, the principal lode along its strike proved to be somewhat irregular, its variations in value and width are only local. Mr. Jules Jadot, the late manager of the mine, informed the author that he had noted no evidence of deterioration of the lode, although the present adit-level had only come upon the apex of the eruptive-mass of gabbro, and therefore its influence on and relation to the ore-bodies could

not well be noted. When the lower adit-level has been holed into the principal lode, it will be possible to determine with certainty its size and its value in depth. The low adit is now driven for a length of 750 feet (230 metres) and has cut two lodes showing only copper-glance; it will reach the third (the most important) lode before the end of 1903. The development workings in this lode (São Luiz) are 650 feet (200 metres) long. It is intended to continue the adit-level to a length of about 3,300 feet (1,000 metres) and it is calculated that it will cut several other lodes, which crop out very promisingly on the surface.

The Cerro Martino mine is situated about 86 miles (142 kilometres) from the Rio Negro station, already referred to, and 81 miles (130 kilometres) from Cachoeira on the Uruguayana railway, which runs from Margem on the Jacuhy river. As already remarked, the geological conditions are somewhat different from those which obtain at the Camaquam deposit, for the conglomerates seem to have suffered very much more from melaphyre, which has spread itself over the two hills, in which the copper-ores are found. The conglomerates, between the two hills, are very fine and may be considered sandstones. They have a dip of about 40 degrees, and the lodes cross them approximately at right angles, as at Camaquam. Most of the copper occurs as glance, and the other constituent minerals of the lodes are iron-pyrites and heavy spar. Analyses made by the author of samples taken by himself gave copper-contents varying between 7 and 25 per cent.

The Primavera mine is situated near Caçapava, in the central chain of hills formed by the Cambrian rocks and granite. The vein of quartz, containing copper-glance and pyrites, and showing sometimes signs of native silver, is situated at the contact of granite and micaceous schists. The copper-glance occurs disseminated through the ore-mass in small nodules, and the total copper-contents may be taken on an average sample as about 7 per cent.

The Cerro do Geraldo deposit is situated about 2½ miles (4 kilometres) in a north-easterly direction from Caçapava. The ore crops out on the summit of a steep hill, and a shaft which has been sunk to a depth of 66 feet (20 metres) shows copper-ore impregnations in the micaceous schists. At the foot of the hill, some copper-glance impregnations have also been noticed, but the mineral is nowhere of any commercial value.

Copper-ores have been found at Lavras and Quarahim, but the author has no reliable information available concerning them.

Carboniferous Deposits.—The two principal coal-deposits are known as São Jeronymo and Candiota, the first situated to the north-east and the other to the south-west of the Serra do Herval.

The São Jeronymo deposit lies about 11 miles (18 kilometres) from the Jacuhy river, with which it is connected by a metre-gauge railway. The coal-seam is 6½ feet (2 metres) thick, and is mined by the pillar-and-stall method, the conditions for successful and economical mining being most favourable. The roof is good, and the quantity of water in the mine very small: no pumps being required as the water can be taken from the sump by a bucket hauled by the winding-engine, working 2 or 3 hours a week. The coal is of a semi-bituminous and schistose character, and must be carefully picked in order to obtain good results.

In 1899, a careful examination of the São Jeronymo coal was made by Mr. Jules Koeber, of Rio de Janeiro, on behalf of the Rio Grande Gas Company, in order to determine its value, as compared with good English coal, for gas-making (Tables I., II. and III.).

TABLE I.—ANALYSES OF SÃO JERONYMO AND ENGLISH COALS.

	São Jeronymo Coal. Gas-work's Sample. Per cent.	São Jeronymo Coal. Coal Co.'s Sample. Per cent.	English Coal. Gas-work's Sample. Per cent.
Hygroscopic water	10·68	15·14	2·70
Volatile matter	23·72	38·78	31·33
Fixed carbon	38·86	37·34	62·16
Ash	26·82	8·78	4·23
Sulphur	1·87	1·43	1·05
Calorific power in calories ...	5,323	6,043	7,769
Specific gravity	1,580	1,580	1,638

These analyses prove that the mineral is not satisfactory as a gas-coal. The great variation in the results of the analyses of the different samples may be explained by the fact that the Coal Company's sample was doubtless made up of picked mineral, whilst that of the Gas Company may be taken as representing the class of coal generally furnished to consumers.

TABLE II. TRIALS OF SÃO JERONYMO AND ENGLISH COALS IN AN EXPERIMENTAL PLANT AT THE GAS-WORKS.

	São Jeronymo Coal. Gas-work's Sample.	São Jeronymo Coal. Coal Co.'s Sample.	English Coal. Gas-work's Sample.
Furnace-temperature, degrees Cent.	1,000	1,000	1,000
Retort-charge, kilogrammes	1	1	1
Duration of experiment, minutes	20	20	20
Gas distilled from 100 kilogrammes, cubic metres	22·60	27·21	31·53
Coke, kilogrammes	64·95	51·45	62·85
Candle-power of gas produced	3·59	10·26	15·17

TABLE III.—ANALYSES OF THE COKES PRODUCED BY DISTILLATION OF SÃO JERONYMO AND ENGLISH COALS.

	São Jeronymo Coal. Gas-work's Sample. Per cent.	São Jeronymo Coal. Coal Co.'s Sample. Per cent.	English Coal. Gas-work's Sample. Per cent.
Hygroscopic water	3.72	2·66	1·29
Fixed carbon	51·30	78·47	92·80
Ash	44·66	19·48	5·86
Sulphur	1·22	1·16	0·90
Calorific power, calories ...	2,333	5,480	7,560

NOTE.—The ash of the São Jeronymo coal was white and calcareous, and that of the English coal was yellow and siliceous.

The quality of the coal can undoubtedly be much improved by picking, and when that is done its utility must be very great in a country where imported coal is so very expensive. It can be sold for 20s. a ton in competition with English coal, which costs from 45s. to 50s. per ton at Porto Alegre.

The output of the mines has averaged between 10,000 and 20,000 tons during the last few years, and the greater part has been used by the Uruguayan railway and native coasting-steamers. Owing to the high percentage of ash in the coal, specially wide grate-bars must be fitted to the boiler-furnaces in which it is used.

An analysis of the São Jeronymo coal made by Mr. Vandecapelle gave the following results:—

	Per cent.
Hygroscopic water	10·4
Volatile matter	23·3
Fixed carbon	40·8
Ash	25·5

The São Jeronymo Carboniferous basin has a very large area, and outcrops of coal occur along the valley of the Jacuhy river.

Exploration-work has been done at Irapuá, near Cachoeira; and the coal has been analysed by Mr. Vandecapelle with the following results:—

	Per cent.
Hygroscopic water	13·85
Volatile matter	19·91
Fixed carbon	34·19
Ash	32·03

The Carboniferous formation in the valley of the rivers Candiota and Jaguarão is very extensive, being about 54 miles (90 kilometres) long by 31 miles (50 kilometres) wide. Many attempts have been made during the last century to work these deposits; and, as far back as 1863, a concession was given by the Imperial Government for the construction of a railway to connect the deposits with a port.

The coal occurs in a bed about 7 feet thick, resting on mica-schists and overlain by a ferruginous sandstone, and it has an inclination of about 10 degrees towards the south-west. The outcrop being very extensive along the sides of the valleys, the conditions for economical working are even better than at São Jeronymo. The bed of coal consists of thin alternating layers, of almost infinitesimal thickness, of carbonaceous and argillaceous matter. Owing to this peculiar structure and the swelling of the argillaceous matter on exposure, the mineral will not bear transport or storage.

The following are analyses of samples of Candiota coal by Mr. Vandecapelle:—

	1 Per cent.	2 Per cent.
Hygroscopic water	15·2	21·8
Volatile matter...	28·5	29·2
Fixed carbon	38·1	41·5
Ash	18·2	7·3

NOTE.—No. 1 was a general sample, while No. 2 was a picked sample.

The analyses show that the quality of the mineral is better than that of São Jeronymo, but the grave defect of its friability on exposure causes it to have little commercial value. Some of the mineral has been used from time to time for the electric-light plant at Bagé, but the results have not been satisfactory.

To use either the São Jeronymo or Candiota coals, a *sine-quâ-non* is the adaptation of the furnaces of the boilers to this poorer coal, by the fitting of a special type of grate-bar and the provision of forced draught.

Miscellaneous Minerals.—Wolfram has been found near Encruzilhada in a vertical quartz-vein, in the granite-rock which could be traced for some distance. On both sides of the quartz-vein, and between it and the granite, small bands of crystalline white mica (muscovite) were found ¾ inch to 1¼ inches (2 to 3 centimetres) thick.

A few feet (3 or 4 metres) below the surface, the wolfram was gradually replaced by copper and iron-pyrites, and black tin has been found in the streams near by, but not in the veins. A parcel of this wolfram-ore, sent to England, contained 69·20 per cent. of tungstic acid and was sold for 9s. 6d. per unit.

Agate is found, in quantity, at Uruguayana, near the boundary between the republic of Uruguay and the state of Rio Grande. Originally, the industry was very prosperous, but latterly it has been in a decadent condition owing to the unremunerative prices ruling for the mineral.

Conclusion.—The author has given as complete and reliable an account as possible of the known mineral-resources of the state of Rio Grande. So little exploration has, however, been carried out, and so exceptionally favourable are both the physical and economical conditions for successful mining, that there is every possibility of a great increase in mining work in the future.

The author gratefully acknowledges the help of several gentlemen in the preparation of this paper, his special thanks being due to Messrs. Jules Jadot and Albert Vandecapelle.

Mr. Robert Normanton (Beverley, Yorkshire) wrote that he had read with great interest Mr. H. Kilburn Scott's paper on "The Mineral Resources of the State of Rio Grande do Sul, Brazil," and having travelled over the country, he could fully endorse and appreciate Mr. Scott's communication with slight exceptions. It is doubtful whether the "bar" of Rio Grande will allow steamers to pass with a tonnage of 5,000 tons: only under very exceptional tides could a vessel of this tonnage pass the bar, but specially constructed German steamers of 2,000 tons go up monthly to the city of Rio Grande. He could fully endorse Mr. Scott's observations, wherein he states that the metalliferous deposits seem to have a close connection with the eruptive rock.

In the Serra Santa Barbara, possibly not visited by Mr. Scott, black basalts and obsidian of a peculiar structure occur. The Serra Santa Barbara is at an elevation of about 1,600 feet (500 metres) above sea-level, trends in a general westerly direction, and is about mid-way from the Serra do Herval and the copper-mines of Camaquam, but at a much higher level than those mines. The latest advice from this zone is that rich copper-ores have been discovered, and he was led to believe that the quantity was large. The Camaquam copper-mines, now worked by Belgians, were visited by him during the exploration-stage, the depth of the excavation being about 16 feet. This property was formerly held on lease by a British company, who executed a certain amount of work, and then abandoned the lease, and something of this nature also took place with the Barcellos Gold-mining Company. About 3 miles from the Barcellos mine are other fine gold-properties, and should the Barcellos mine commence operations again, their mill could be supplied with ore from outside mines and used as a customs mill. By the opening of the Great Southern Railway, the position of various properties has been greatly improved. Mr. Scott was perfectly correct when he stated that but little exploration had been carried out, barely a scratching of the ground, with the exception of the Camaquam copper-mine, although for mining, there were most favourable conditions, and as regards climatic conditions the Rio Grande do Sul is a white man's country.

Mr. Louis Cousin (Brussels) wrote that the description of the Camaquam copper-mines is accurate, with the exception of the tenour of gold in the ore: some time ago, the ore contained 15 grains (1 gramme) of gold per ton per unit of copper, and concentrates of 30 per cent. of copper contained 19 pennyweights (30 grammes), but that percentage had not been maintained since Mr. Scott's visit to the mine. The continuity of the lode in depth had now been proved by the lower adit (cross-measures drift) which had met the São Luiz lode at a depth of 394 feet (120 metres) below the surface.

Mr. James Barrowman (Hamilton) pointed out that the specific gravity of the coal appeared to be exceptionally high.

The President (Sir Lindsay Wood, Bart.) remarked that it was probably a slaty coal.

Mr. H. D. Hoskold (Buenos Aires) wrote that Mr. H. Kilburn Scott's paper was opportune, interesting and welcome, because it dealt with a country, the mineral resources of which, in all probability, may be large. He had, therefore, rendered a great service in bringing the subject of his paper before the members.

Doubtless Brazil is, more or less, in the same position as various of the other South American republics, that is, the country is not thoroughly explored, the mines are not much developed, and there is a want of accurate, detailed, official mining statistics from the time when mining was first commenced in a formal manner. No doubt Mr. Scott must have felt this, for it is to be supposed that if it had been otherwise he would have been able to include such data in his paper, not only from Rio Grande do Sul, but also from the other mining states of Brazil. He (Mr. Hoskold) had taken considerable pains to procure a complete copy of the official mining statistics of Brazil, but had failed to do so. It must be evident that the value of a mine or mines depends altogether upon the annual production and the net benefit derived over a series of years in the past, as well as on future prospects. For the object of determining the comparative advantages to be derived from the expenditure of capital which may be devoted to the exploitation of mines and the reduction of the ores in various countries; and, consequently, to aid in selecting mines in a country with the best conditions, mining statistics are not only important but absolutely necessary.

The nature of the mining laws of a foreign country may, also, affect the profitable working of mines to a considerable extent. Before, therefore, any serious mining operations are entered upon, such legislative measures as may exist should be thoroughly examined. Mr. Oswald Walmesley, the author of an excellent *Guide to the Mining Laws of the World*, states that Brazil possesses no code of mining laws; but that various decrees or isolated legal dispositions have been made at different periods, regulating mining in that country.

It is curious to note that in various of the South American republics anything and everything of a black or carbonaceous nature found deposited in the rocks is considered, by those who are not practical geologists and mining engineers, to belong to the Carboniferous formation. But this is only true in a limited sense, that is, that certain more recent formations may contain coal, as is the case in the Argentine and Chilian republics, without

belonging to the great Carboniferous formation, or of the age of that found in Great Britain and other countries. It is, therefore, highly probable that the coal-deposits mentioned by Mr. Scott as existing and extending "along the northern side of the Serra do Herval," where the principal coal-mine, São Jeronymo, is being worked, do not belong to the Carboniferous system. However, the fossil fauna and flora, if any exist in the district referred to, would settle the question definitely. Mr. Scott has not referred to this interesting and important palæontological evidence; but he does say, "At one place, an auriferous quartz-vein cuts the granite and metamorphic rocks, close to their contact with the Carboniferous formation. In fact, coal, mined about ½ a mile (1 kilometre) distant from the auriferous deposit, is used to drive a 5 heads stamp-mill at the mine." Doubtless this statement would appear curious to many and, without more explanation, would not be well understood, for it is not a common thing to find "granite and metamorphic rocks, close to their contact with the Carboniferous formation."

When officially representing the mining and metallurgical industries of the Argentine Republic at the Chicago Exhibition in 1893, and in the character of a member of the International Jury of Awards, he (Mr. Hoskold) had frequent occasion to inspect and report upon the exhibits in the sections of various nations for awards. On visiting the Brazilian mining section, his attention was particularly directed to a series of beautifully drawn maps and sections of the São Jeronymo coal-mines, and to his great surprise discovered that the seam of coal had been deposited upon a thin band of micaceous schist, and that this latter rested immediately upon a granite-base. Not being satisfied with the first casual examination of the sections, other inspections of them were made, and finally a copy of the whole procured. The coal-seam was represented as existing in basin-form, of which there were three in continuous order on the section and under the same conditions; but they were disconnected one from the other by denuding influences which had, in former geological epochs, carried away the more elevated parts exposed to its effects. Unfortunately, the copies of these plans and sections have been either lost or mislaid, so that, at present, it is not possible to refer to them for verification. The data now offered confirm, in a general manner, the indications made by Mr. Scott.

At the time when he (Mr. Hoskold) examined the geological

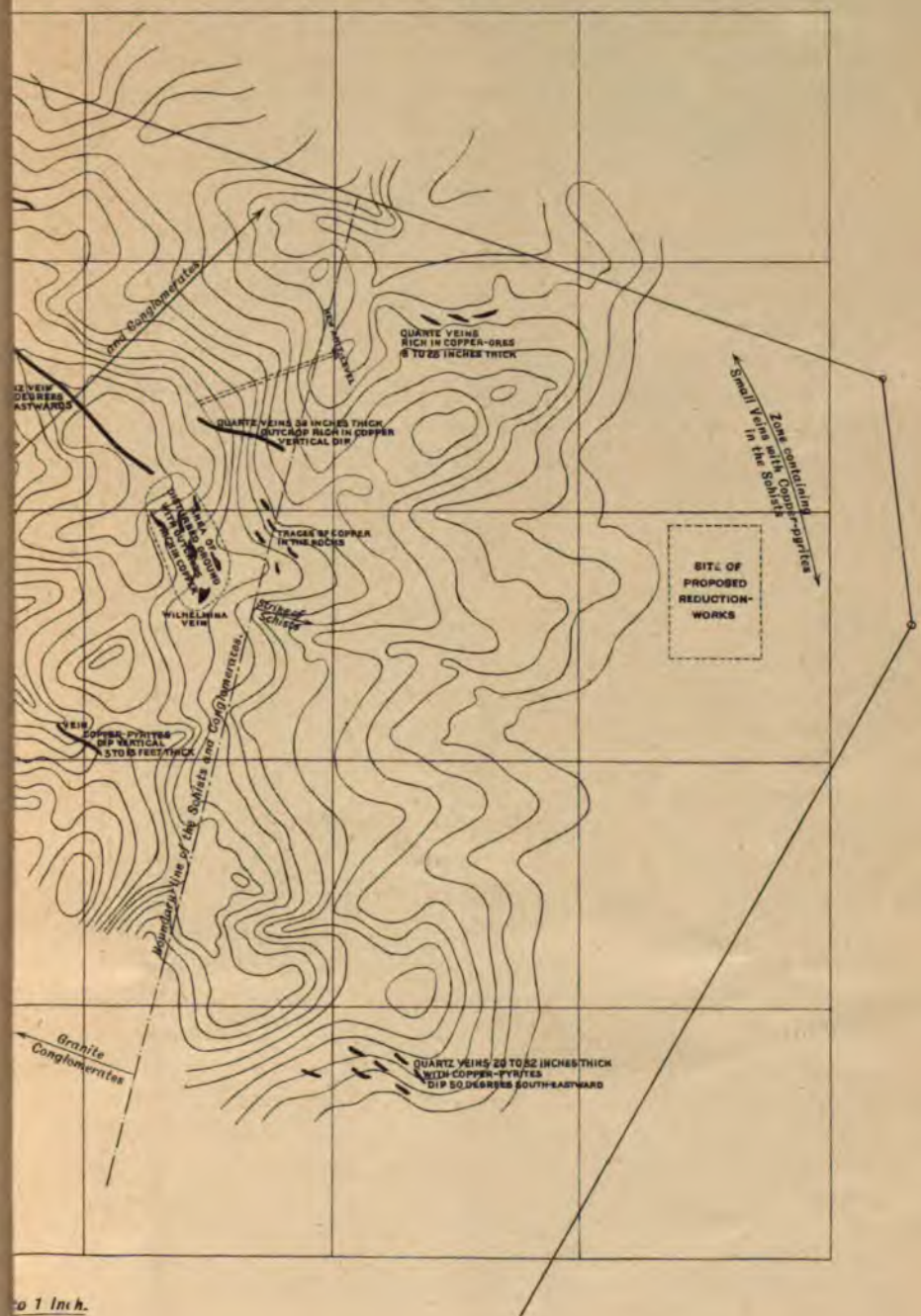
section of these coal-measures, it appeared to him that the micaceous-schist, under the coal-seam, was much too thin to allow of the growth of an immense tropical forest of trees and other vegetable products such as would have been sufficient to form a deposit of coal like that now found in the mine of São Jeronymo, which, according to Mr. Scott, has a thickness of 6½ feet. One of the greatest authorities upon the time necessary to form a bed of coal was Sir J. W. Dawson, and in one of his scientific discussions he said "We may safely assert that every foot of thickness of pure bituminous coal implies the quiet growth, and fall of at least 50 generations of *Sigillaria*, and therefore an undisturbed condition of forest-growth enduring through many centuries." Taking this estimate as a basis, the bed of coal in the São Jeronymo mine must have required 325 generations of forest-growth. It is, therefore, evident that the vegetable-matter, originally forming the coal-seam under consideration, must have been derived from forest-growths situated at a distance from the locality of the coal-seam, and that it must have been transported by floods and deposited in the locality and under the conditions in which it is now found. Doubtless, such a process is, in a great part, the reason why the coal-seam is found in a schistose condition and, consequently, much inferior to British coal dating from the great Carboniferous period. Considering, therefore, all the conditions under which the coal in the São Jeronymo district exists, he (Mr. Hoskold) is of the opinion that it does not belong to the Carboniferous system.

After having studied this question for many years, he is also convinced that the same remarks apply to the coal-deposits existing in the Argentine, Chilian and Uruguayan republics.

Mr. M. H. Mills (Mansfield), in moving a vote of thanks to Mr. Scott for his interesting paper, remarked that there was plenty of work for their children, and for their children's children, if not in Great Britain, then in Brazil and other countries. They might also feel secure that their own coal-fields would continue to hold their own as to quality, if not in quantity.

Mr. C. C. Leach seconded the resolution, which was cordially approved.

FIG. 2.—PLAN OF THE COPPER-MINES OF CAMAQUAM.



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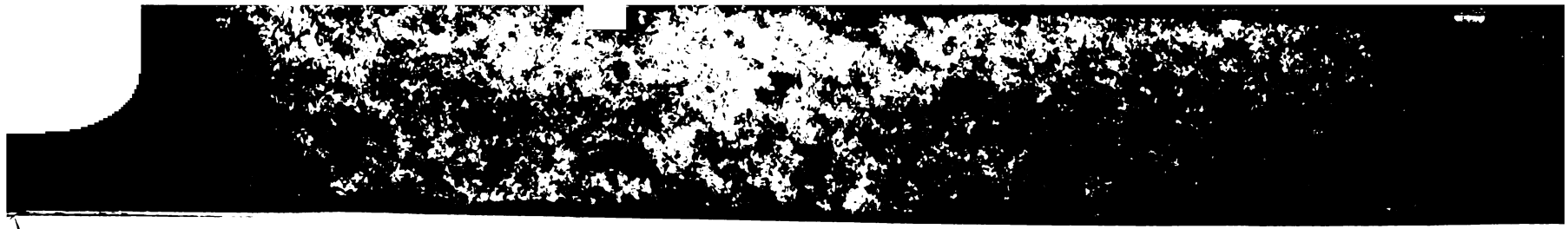

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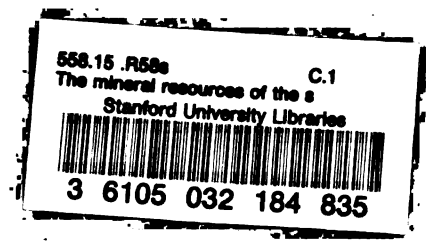
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